

# CLAIMS

What is claimed is:

1. A method of determining value-at-risk, comprising the steps of:  
electronically receiving financial market transaction data over an electronic network;  
5 electronically storing in a computer-readable medium said received financial market transaction data;  
constructing an inhomogeneous time series  $z$  that represents said received financial market transaction data;  
constructing an exponential moving average operator;  
10 constructing an iterated exponential moving average operator based on said exponential moving average operator;  
constructing a time-translation-invariant, causal operator  $\Omega[z]$  that is a convolution operator with kernel  $\omega$  and that is based on said iterated exponential moving average operator;  
15 electronically calculating values of one or more predictive factors relating to said time series  $z$ , wherein said one or more predictive factors are defined in terms of said operator  $\Omega[z]$ ;  
electronically storing in a computer readable medium said calculated values of one or more predictive factors; and  
20 electronically calculating value-at-risk from said calculated values.

2. The method of claim 1, wherein said operator  $\Omega[z]$  has the form:

$$\begin{aligned}\Omega[z](t) &= \int_{-\infty}^t dt' \omega(t-t') z(t') \\ &= \int_0^{\infty} dt' \omega(t') z(t-t').\end{aligned}$$

3. The method of claim 1, wherein said exponential moving average operator  $\text{EMA}[\tau; z]$  has the form:

$$\text{EMA}[\tau; z](t_n) = \mu \text{EMA}[\tau; z](t_{n-1}) + (v - \mu) z_{n-1} + (1 - v) z_n, \text{ with}$$

$$\begin{aligned}\alpha &= \frac{\tau}{t_n - t_{n-1}}, \\ \mu &= e^{-\alpha},\end{aligned}\tag{23}$$

where  $v$  depends on a chosen interpolation scheme.

4. The method of claim 1, wherein said operator  $\Omega[z]$  is a differential operator

5  $\Delta[\tau]$  that has the form:

$$\Delta[\tau] = \gamma(\text{EMA}[\alpha\tau, 1] + \text{EMA}[\alpha\tau, 2] - 2 \text{EMA}[\alpha\beta\tau, 4]),$$

where  $\gamma$  is fixed so that the integral of the kernel of the differential operator from the origin to the first zero is 1;  $\alpha$  is fixed by a normalization condition that requires  $\Delta[\tau; c] = 0$  for a

constant  $c$ ; and  $\beta$  is chosen in order to get a short tail for the kernel of the differential operator

10  $\Delta[\tau]$ .

5. The method of claim 4 wherein said one or more predictive factors comprises

a return of the form  $r[\tau] = \Delta[\tau; x]$ , where  $x$  represents a logarithmic price.

15 6. The method of claim 1 wherein said one or more predictive factors comprises

a momentum of the form  $x - \text{EMA}[\tau; x]$ , where  $x$  represents a logarithmic price.

7. The method of claim 1 wherein said one or more predictive factors comprises

a volatility.

20 8. The method of claim 7 wherein said volatility is of the form:

$$\text{Volatility}[\tau, \tau', p; z] = \text{MNorm}[\tau/2, p; \Delta[\tau'; z]], \quad \text{where}$$

$$\text{MNorm}[\tau, p; z] = \text{MA}[\tau; |z|^p]^{1/p}, \quad \text{and}$$

25  $\text{MA}[\tau, n] = \frac{1}{n} \sum_{k=1}^n \text{EMA}[\tau', k]$ , with  $\tau' = \frac{2\tau}{n+1}$ , and where  $p$  satisfies  $0 < p \leq 2$ ,  
and  $\tau'$  is a time horizon of a return  $r[\tau] = \Delta[\tau; x]$ , where  $x$  represents a logarithmic price.